GROUNDWATER AND PUBLIC POLICY LEAFLET SERIES

This series of seventeen leaflets is part of a set of educational materials on rural groundwater quality issues developed by the Groundwater Policy Education Project. This ASCII version of the leaflet series contains the complete text, but none of the graphics found in the original. Leaflets may be purchased from the Freshwater Foundation, Spring Hill Center, 725 County Road Six, Wayzata, Minnesota 55391, Telephone: (612) 449-0092. Reproduction and publication, in whole or in part, of adaptation for specific audiences is encouraged. Authors should be properly cited, with the Groundwater Policy Education Project identified as the source.

The Groundwater Policy Education Project is a joint effort of Cooperative Extension, the Freshwater Foundation, and the Soil and Water Conservation Society. These organizations joined together to create educational materials that would increase the abilities of citizens and local and state officials to make informed groundwater policy decisions.

WHAT IS GROUNDWATER?

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To better appreciate the importance of groundwater management and policymaking, we must first understand what groundwater is and why the protection of groundwater is such a critical concern.

Many people think of groundwater as underground lakes or streams. While there are such things in areas underlain by cavernous limestones or lava flows, most groundwater is simply water below the land surface that fills the spaces between rock grains or the cracks and crevices in rocks.

Such openings are most common near the land surface. At great depths, these openings are closed due to pressure of overlying materials. This closure may occur at a few hundred feet, although in places water-bearing openings are found to depths of several thousand feet.

The amount of water that rock can contain depends on its porosity, or the ratio of open space to the total volume of the rock. In sand and gravel, this ratio generally is 30 to 40 percent. However, in rocks where cracks represent the only open spaces, such as tightly cemented sedimentary rocks, the porosity commonly is 1 percent or less. Nevertheless, these rocks may yield usable amounts of water.

Where Does Groundwater Come From?

Rain and snowmelt percolating down through the soil are the sources of groundwater. Much of the water entering soil is consumed by plants. A small amount is held on the soil grains by capillary forces. The rest moves downward to the zone of saturation, the area in which all openings are filled with water. The top of the zone of saturation is called the water table, where the pressure is the same as that of the atmosphere.

How Does Groundwater Move?

Groundwater usually is in motion, flowing from upland areas of recharge to lower areas where it may discharge to a spring, a stream or other body of surface water. The rate of groundwater flow is determined by the the slope of the water table and the permeability of the materials through which it flows. Groundwater flow rates range from inches per year to feet per minute.

For water to move freely through rock, the openings must be interconnected and large enough so that wall friction does not impede the flow. Rocks that contain many connected openings, of a size sufficient to permit water to move freely, are called permeable. Even such rocks as granite, which have no spaces between individual grains, are permeable if broken by fractures large enough to permit water to pass freely. Although clay and other fine-grained materials have high porosity, they transmit water very slowly, because their pores are so small that wall friction greatly impedes water movement.

What Are Groundwater Basins and Aquifers?

Just as a watershed is the area on the land surface that contributes runoff to a stream, a groundwater basin is the area within which recharge contributes to a groundwater body having a common area of discharge, such as a spring, stream or swamp.

Aquifers consist of permeable rocks or granular materials that transmit water freely. They function in two very important ways. First, they transmit groundwater from areas of recharge to points of discharge. Second, they provide storage for large volumes of water. In a sense, they act as both pipes and storage tanks.

Unconfined aquifers are those in which atmospheric pressure changes transmit downward through an unsaturated zone of soil or rock to the water table. Unconfined aquifers yield water to wells by draining the material surrounding the well. When the water table rises or falls, the change in storage is equivalent to the volume of pore space saturated or drained.

Where a relatively impermeable material (such as clay) overlies an aquifer and impedes the free movement of air or water, the aquifer is termed "confined" or "artesian." In such cases, water is confined under pressure, as in a pipe system. Confined aquifers yield water by compression of the aquifer, slight expansion of the water, drainage of adjacent unconfined zones, and leakage through confining layers.

In general, a confined aquifer acts like a water-filled bladder that loses volume as water is expelled by squeezing the bladder. In many places, the pressure in confined aquifers is sufficient to cause the water to flow at land surface.

What Else Is in Groundwater - Besides Water?

Groundwater nearly always contains more dissolved minerals than nearby streams, although both originate as precipitation. The main reason for this is that water passing through the soil dissolves large amounts of carbon dioxide generated by soil microorganisms decomposing organic matter. This carbon dioxide dissolves in soil moisture, producing a weak carbonic acid solution that attacks carbonate and silicate minerals of calcium, magnesium and sodium, causing their solution. Groundwater also stays in contact with the surrounding rocks much longer than surface water, which allows more time for chemical reactions to occur.

In addition to dissolved minerals, infiltrating water also carries organic matter from the soil down to the groundwater. Organic acids, formed through the decay of organic matter, bacteria, fungi and viruses, may be leached to the groundwater. For the most part, these natural organic compounds and living organisms are attached to or filtered out by mineral grains, so that, after traveling a few tens of feet, most organic matter is removed from groundwater. Where groundwater flows through large openings, though – such as in limestone - organic matter and organisms may persist over long distances.

Is Groundwater Quality Superior to Surface Water Quality?

Groundwater has both advantages and disadvantages when comparing its quality to that of surface water. Advantages include the following:

- Passage through soil and granular materials allows the filtering of microorganisms and minute particles, as well as the attachment of organic compounds and some metals to clay minerals.
- Temperature and chemical quality are relatively constant.
- Some types of pollution, especially airborne contaminants, are seldom a concern.
- Spread of pollution is slow.
- Sediment content is generally negligible.
- Supply generally is unaffected by short-term fluctuations in climate.

Groundwater does have several disadvantages in terms of water quality. First, dissolved mineral content and hardness are higher than in nearby surface water. Second, once groundwater is contaminated, cleanup is slow and difficult.

Why Is Groundwater Contamination a Particular Concern?

Contamination of groundwater by human activity is a severe problem because contaminants generally travel unnoticed until detected in a water supply well. Once contaminated, an aquifer is difficult and expensive to clean up. The contaminant disperses in the groundwater, is difficult to remove, and may persist for decades. In almost all cases, prevention is simpler and cheaper than the cure.

Contaminants include an almost endless list of inorganic chemicals, synthetic organic chemicals, petroleum products, biological matter, radioactive compounds, and even physical loads such as heat. The impacts on groundwater may range from relatively harmless aesthetic effects, such as unpleasant taste, to imminent health hazards.

Some contaminant problems due to geography, geology or industrial location are unique to specific parts of the country. Examples include acid mine drainage in the Appalachian coal fields, sea water intrusion in coastal areas, and irrigation return waters. Other sources of contamination, such as septic tank effluents, municipal landfills and underground petroleum storage tanks, are found throughout the nation.

Principal sources of groundwater contamination, in order of national prominence, are:

- industrial wastes
- municipal landfills
- agricultural chemicals
- septic system and cesspool effluents
- leaks from petroleum pipelines and storage tanks
- animal wastes
- acid mine drainage
- oil field brines
- saltwater intrusion
- irrigation return flow

While spills of industrial wastes and leakage from landfills may receive the most attention, it is the more common contamination sources, such as septic tanks, agricultural chemicals, and animal wastes, that account for the most frequent and widespread contamination.

About 40 million people in the United States depend on septic tanks or cesspools, and this same population relies on groundwater for drinking water. Even with good design, dissolved mineral contaminants from these disposal systems can reach groundwater. However, properly designed waste systems do assure the filtering, attachment or chemical alteration of such constituents as organic compounds, bacteria and viruses before the effluent reaches the groundwater. Periodic water testing can reveal the presence of contaminants in a well or spring water supply.

What Role Should Groundwater Play In Planning and Decision-Making?

Groundwater has often been slighted in water supply planning and management. For a long time, it was believed that groundwater could not be as easily evaluated as surface water, in terms of its availability, development, chemical quality and the economics of recovery. On the contrary, new hydrogeologic information and understanding, along with substantial progress in analytical capability, have improved the ability to plan, develop and manage groundwater. Scientific analysis of groundwater systems has opened the door to more effective use and protection of groundwater.

Groundwater hydrology is an interdisciplinary mix of the physical, biological and mathematical sciences. New concepts and methods have improved investigation and problem solution. Simulation methods developed within the past 25 yearspermit revealing model analysis of groundwater systems and their interconnections with surface water. Modeling enables prediction of the effects of pumping and waste disposal on groundwater. It also allows greater consideration of alternative management plans.

Inadequate communication between the groundwater expert and the planning expert is partly responsible for the lack of integration of groundwater into water resources planning. Closer affiliation of these experts is fostering increased mutual understanding of groundwater and its important role in national water supply. Groundwater is now recognized to be a fundamental component in the comprehensive joint management of land, water and waste throughout the nation.

The magnitude and complexity of groundwater problems continue to grow. For this reason, expanded efforts are needed to ensure adequate groundwater data and information, and to bring groundwater into the mainstream of planning, management and decision-making at all levels of government.

Groundwater quality and related public policy issues are the theme of the March-April 1990 issue (Volume 45, Number 2) of the Journal of Soil and Water Conservation. This special issue, titled "Rural Groundwater Quality Management: Emerging Issues and Public Policies for the 1990s," may be ordered from the Soil and Water Conservation Society, 7515 N.E. Ankeny Road, Ankeny, Iowa 50021-9764, for $12.

Recommended Further Reading

National Water Summary 1986: Hydrologic Events and Groundwater Quality. U.S.

Geological Survey Water Supply Paper 2325. U.S. Geological Survey, 1988.

National Water Summary 1984: Hydrologic Events, Selected Water Quality Trends

and Groundwater Resources. U.S. Geological Survey Water Supply Paper 2275.

U.S. Geological Survey, 1985.

Groundwater. U.S. Geological Survey, 1986.

Groundwater and the Rural Homeowner. U.S. Geological Survey, 1989.

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